Semester 2 Examinations 2011/ 2012

Exam Code(s)	4IF
Exam(s)	B.Sc. in Information Technology
Module Code(s)	CT420
Module(s)	Real-Time Systems
Paper No.	1
Repeat Paper	N
External Examiner(s)	Prof. Michael O'Boyle
Internal Examiner(s)	Prof. Gerard Lyons Dr. Michael Madden Dr. Hugh Melvin Dr. Michael Schukat

Instructions: Answer 2 questions in section A and 2 questions in section B. All questions carry equal marks.

Duration	3 hours
No. of Pages	6
Discipline	Information Technology

Requirements:
MCQ
Handout
Statistical/ Log Tables
Cambridge Tables
Graph Paper
Log Graph Paper
Other Materials

Release to Library: Yes [X] No [ ]

Section A – Soft RTS

Q1
(i) Distinguish using examples between a hard and soft RealTime Systems RTS. Explain why many hard RTS use a cyclic executive approach to scheduling whereas many soft RTS utilise a real-time operating system.

[10]

(ii) Comment on the relationship between the *sample rate* and *response time* of a RTS using an example to illustrate your answer.

[5]

(iii) As senior technical advisor, you are asked to test/evaluate a range of new VoIP phones for your organisations communications infrastructure. Describe using diagrams a testbed that you might develop for this purpose and what metrics you would use for your tests.

[15]

(iv) Briefly outline how the Network Time Protocol (NTP) operates to maintain synchronisation to Universal Coordinated Time (UTC).

[10]

Q2
(i) Many RTS have specific requirements for both **time and timing** synchronisation. Distinguish clearly between these two concepts.

[5]

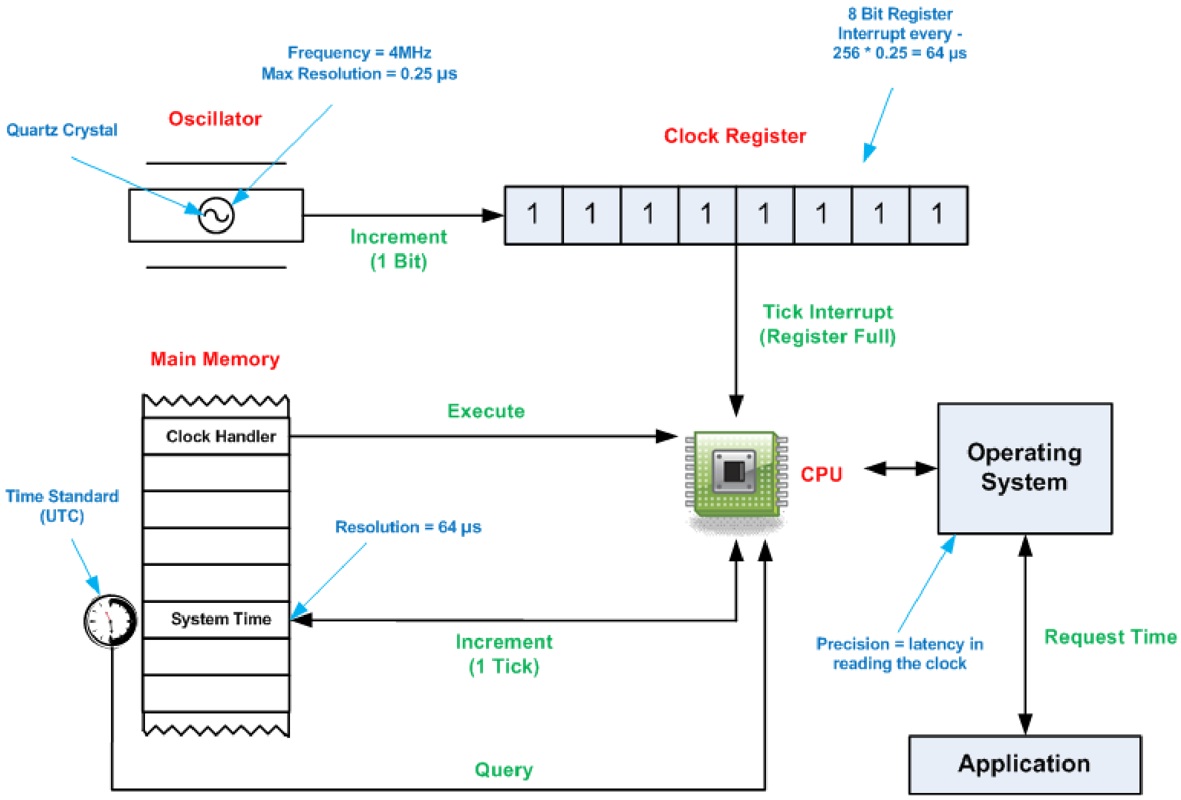
(ii) Using each of the following examples, outline and explain firstly - whether time, timing, or both types of synchronisation are important and secondly - the level of synchronisation required:

- Electrical Power Line Fault Detection System
- 2-out-of-3 (2v3) CPU voter System for Fuel Management System in a Power Station
- MMOG (Massively Multiplayer Online Gaming) Server servicing players from across the globe

[15]

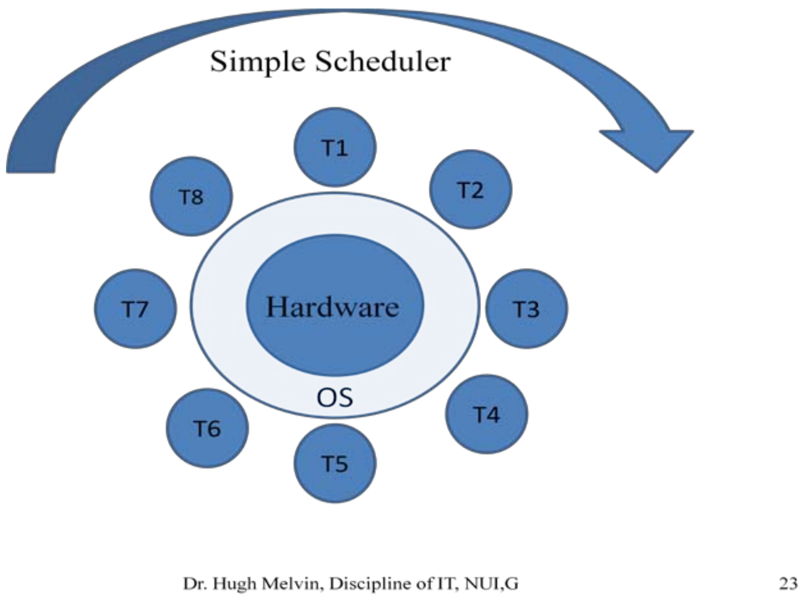
(iii) The diagram overleaf outlines a high level view of a typical computer system clock. Describe in some detail how it operates.

Section continues on next page.



[10]

(iv) Explain briefly how the above design directly impacts on clock granularity/resolution. Show also how clock granularity can impact on Real time system responsiveness via Operating System scheduling/time-slicing, using diagram below to illustrate your answer.



[10]

Section continues on next page.

Q3

(i) In the context of voice communication, distinguish between intrinsic and perceived Quality-of-Service (QoS), outlining also how they can be measured.

[10]

(ii) For Voice over IP, what do you consider as acceptable intrinsic QoS? Briefly explain your answer.

[5]

(iii) As a senior network designer for an IP communications provider, you are asked to outline a complete end-to-end infrastructural design for a potential Irish client company that wishes to implement an all-IP based conferencing (voice/video) system. The company will have two large facilities, in Dublin and Galway, each with their own LAN. Your design should address the following challenges:

- How VoIP phones chosen can maximise voice quality
- How QoS will be achieved across company LANs
- How QoS will be achieved across intermediate WAN. You can assume that your company uses DiffServ in its IP network.

[25]

Section B – Hard RTS

Q4
(i) How can the Hamming (7, 4) code be used to encode 8-bit data? What error correcting and error detecting capabilities does the resulting encoding scheme have?

[8]

(ii) Define a set of five 8-bit long code words that have a Hamming distance of 3 or bigger.

[5]

(iii) Using examples discuss 2 typical *fault latency* scenarios in a stack overflow situation.

[8]

(iv) Assess if and how such stack overflows can be avoided or detected via disciplined programming, compiler support or operating system support.

[10]

(v) A 6 byte wide data buffer is shared by 3 concurrent processes to exchange data between each other. Under what circumstances does this setup result in a race condition and what mechanism does POSIX provide to resolve it? Provide code snippets to support your answer.

[9]

Q5
(i) How does static software redundancy using N-version programming work and what kind of voter types can be used?

[8]

(ii) Using the calculation of the factorial n! of a non-negative integer n as an example implement a 3-version programming solution that provides static software redundancy. Outline 3 distinct functions to calculate n! and choose/implement an appropriate voter.
Hint: n! = 1 x 2 x ... x (n - 1) x n), e.g. 0! = 1; 1! = 1; 2! = 2, 3! = 6, 4! = 24, etc.

[12]

(iii) What is meant by the *priority inversion problem* and how can it be solved? Use an example to illustrate your answer.

[10]

(iv) Discuss in detail how a real-time OS kernel can implement the *priority ceiling protocol.*

[10]

Section continues on next page.

Q6

(i) Schedule the 4 tasks in Table 1 below using RM (rate monotonic) and EDF (earliest deadline first) scheduling.

[10]

(ii) Using the data in Table 1 below calculate the overall CPU utilisation and do an RM scheduling analysis.

[12]

(iii) How is graph-based bound calculation used to perform a WCET (worst case execution time) analysis of program code? Use a nested if-the-else code snippet to illustrate your answer.

[9]

(iv) Phobos-Grunt was an attempted Russian space mission to Phobos, one of the moons of Mars. The robotic probe was launched on 9 November 2011 but subsequent rocket burns intended to set the craft on a course for Mars failed, leaving it stranded in low Earth orbit. The probe fell eventually back to Earth and burned up in the atmosphere. Officials blame *soft errors due to alpha particle impact* for the mission failure. Explain what is meant by this and outline how soft errors can have such a catastrophic effect.

[9]

Task	Period	Execution Time
1	20	100
2	40	160
3	80	300
4	100	400

Table 1